ENGINEERING CASE LIBRARY

ECL 149A

DESIGN OF A BALL TRANSFER UNIT FOR AIR CARGO (A)

Westscope is one of the companies which was requested to quote on a ball transfer unit for the cargo systems on Boeing 747. The development of this unit by Westscope is described.

 Written by R. K. Ganeriwal under the direction of Dr. Henry O. Fuchs with support from the National Science Foundation. The cooperation of Mr. Bud Cain and Mrs. Diana Jaye of Westscope, Mr. C. Y. Joe, Lloyd Eber, and Ron Wallace of the United Air Lines in San Francisco is gratefully acknowledged.

DESIGN OF A BALL TRANSFER UNIT FOR AIR CARGO

"Design, develop, and get products to the customer quickly": This has been the philosophy at Westscope since its founding in 1962. Bud Cain, the president of Westscope, has applied this philosophy to all the products developed by the company; the ball transfer unit developed for Boeing is an example of such a product.

Westscope is a subsidiary company of Bearings, Seals, & Gears, Inc. with a total of 30 employees of whom 10 are engineers. Westscope's main business consists of design and development of bearings, seals, gears, and applications of these items.

"We offer specialized engineering assistance in solving mechanical problems involving the use of bearings, seals, and gears or a combination thereof," according to Bud Cain. The firm gets 40% of its business from the aerospace industry. Westscope supplies a variety of parts to Boeing and to the subcontractors of Boeing.

The company was founded by ten men, all of whom were co-workers in a Midwestern firm. The founders are still the main stock holders and are currently scattered in the Western states as sales representatives of the company. All of these men actively participate in establishing the long term goals and policies of the company.

When a sales engineer discovers an opportunity for a sale, he first contacts Bud Cain in Redwood City. The lead is evaluated on the basis of future market potential and of the development and manufacturing costs involved. A decision is made on the basis of this evaluation; usually within a week in accordance with the company's philosophy of minimum time delay.

After initial development of the product, the prototype units are built in Westscope's shop in Redwood City. Initial testing is done by the company and later presented to the customer for approval. Tooling and the selection of manufacturing techniques for quantity production are the final steps. In addition to manufacturing in Redwood City, the company contracts out a considerable amount of work. Some of this work goes to local companies, some to major concerns

in England and Switzerland for whose special products Westscope serves as sales representative.

One of Westscope's offices is located near Seattle, Washington, where Jerry Carlson, a vice president of the company, serves as the sales representative. Jerry maintains contacts with Boeing engineers to keep abreast of the latest developments and the need for vendor services at Boeing. Jerry is sometimes able to obtain advance leads and thus provide Westscope with extra time for development of the product.

In February of 1967, Bud received an inter-office letter from Jerry which described the ball transfer unit which was under consideration for use on the Boeing 747. This letter is attached in Exhibit A-1. It should be noted that this was at an early stage of design work on the cargo handling system. It would normally take approximately two months for the company to complete the formal drawings which would be sent to vendors for quotations. Jerry had obtained information contained in Exhibit A-1 during his informal talks with the engineers on the cargo system of the new jumbo jet which was under development at that time.

Exhibits A-2 and A-3 show the cargo compartment in a Boeing plane. The pallets upon which the cargo rests travel on ball transfer units and rollers. Ball transfer units are utilized near the door area because of the capability of these units to transfer loads in any horizontal direction. Rollers, which cost less, are used in the gallery where the loads move back and forth only. A brief description of the principle of the ball transfer unit is included in Exhibit A-4.

An earlier ball unit and other components of the cargo section in Boeing 707, 727, and 737 jet planes are shown in view B of Exhibit A-5. The various components are individually installed in the plane. The spring is placed in a cavity in the floor. The ball unit and the retaining ring are then installed and pressed down. The retaining ring has projections corresponding to slots on the floor panel. The installation is completed by rotating the retaining ring to an orientation for proper engagement and finally, inserting a screw to prevent rotation.

One of the main shortcomings of this design is the cumbersome installation and replacement procedure described

above. It is estimated that each installation takes approximately one minute (an aricraft has about 1000 units and as many as 250 units are replaced in servicing the plane after 100 hours of operation.) In addition, numerous problems are involved with components of this system. The retaining ring (Exhibit A-5) is made of Lexan, a low strength brittle material susceptible to cracking and breaking. The purpose of the spring is to provide flexibility in the vertical plane so that the units projecting higher depress to provide an even distribution of the load. However, there is no provision in this design for preventing the ball unit from being depressed so far that the metal pallets ride in contact with the retaining ring. The result is a great deal of wear and tear and damage to the retaining rings. There are also problems involved with the assembly of these components on the plane. There are incidents where the assembled units operate very roughly and in some cases completely jam because of improper assembly. In such instances, the metal pallets are forced to slide on these jammed units causing considerable damage to the pallets.

For these reasons, Boeing's engineers were considering a preassembled, self-contained, all metal unit which could be retained by a snap-in mechanism. The preassembled units not only eliminate the excessive time required for assembling units on the plane, but in addition, prevent mishaps during the assembly. Securing the units to the floor by a snap-in mechanism was desirable to further reduce the installation time. These features are described in the first inter-office letter from Jerry, shown in Exhibit A-1.

From Jerry's description of the potential market for such a ball transfer unit, there was no hesitation at Westscope to proceed with the development immediately. Because of the prospects, Bud decided to give his personal attention to the job. The aim was to make a preliminary design proposal to the Boeing engineers as quickly as possible to show the company's initiative and interest in supplying the item to Boeing. Jerry submitted drawings and stayed in contact with the Boeing engineers to keep Bud up to date on the developments. Excerpts from one of the letters from Jerry written two months after his initial lead are included in Exhibit A-6. Exhibit A-7 shows the formal request for quotation from Boeing. It mentions attached sketches. These sketches had been sent earlier by Jerry and are included in Exhibit A-6 as part of Jerry's letter.

Westscope's response to Boeing's request for quotation and the subsequent developments are included in Part B of the case.

LIST OF EXHIBITS

EXHIBIT

ECL 149A

BEARINGS, SEALS, & GEARS, INC.

INTER-OFFICE CORRESPONDENCE

DATE February 27, 1967

TO Westscope, Inc.

ATTENTION Bud Cain

COPIES George Goodrich

SUBJECT Boeing Airplane Div.
Renton, Washington

REFERENCE

Enclosed is a sketch showing a ball transfer unit for use on the 747 aircraft.

It utilizes a 1" diameter hollow ball and will also retain a shell and spring, thus being a self-contained unit that can be easily inserted or removed from the lower cargo holds.

All 747 aircraft being built whether passenger or cargo models will have this ball transfer unit. Approximate number per airplane would be 1000 or more, thus the potential market is extremely lucrative considering that the integral spring and housing will yield a higher unit price.

The market potential would be for 100,000 units per year for a total business volume of approximately $500,000 per year. Considering that Boeing wants to build at least 400 or 500 aircraft the total market will be probably approximately $2.5 million to $3.0 million.

The writer would appreciate your reviewing this design which basically is a snap-in assembly between channel sections. The slotted tabs would depress inward and then spring outward to lock in the bottom of the channel which has a mating slot.

What is required is a drawing defining this part and assigning a part number so that it can be given to Boeing. Eight copies of our drawing showing a part number should be sent to the writer for relay to Boeing.

Our complete part would include the ball transfer unit, spring and canister housing. Please return the drawings by Feb. 28, 1967.

JAC:dcs
Enc.

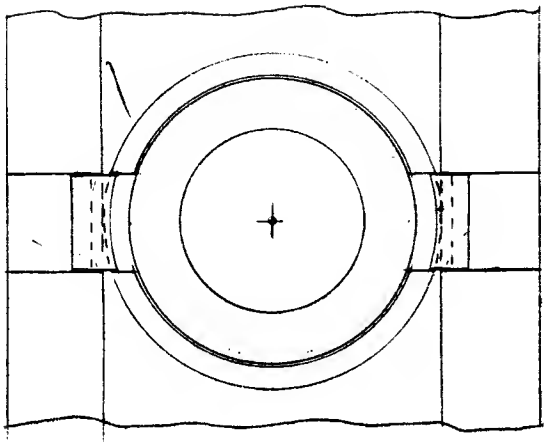
J. A. Carlson

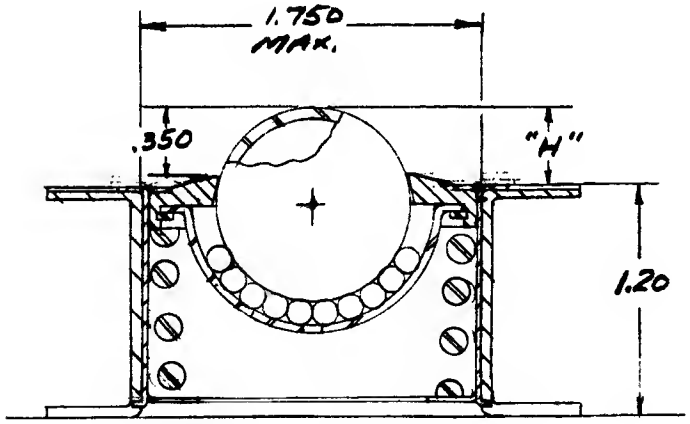
Letter from Jerry Carlson to Bud Cain, dated 27 February 1967

EXHIBIT A-1

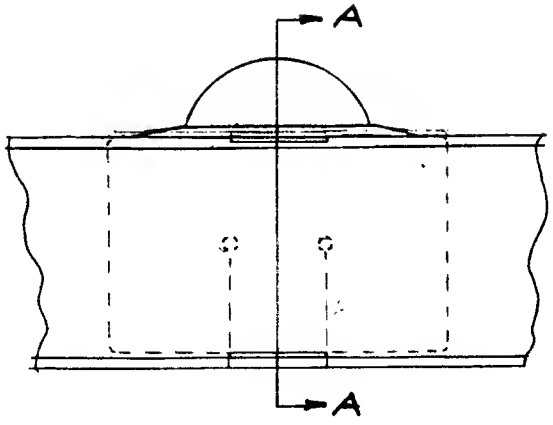
747 Ball Transfer Unit

Full Scale





Section A-A



Stickout "H"	Spring Load
.40	27 #
.30	34 #
0	56 #

Unit Weight ≈ .22 #

Sketch sent by Jerry Carlson to Bud Cain, 27 February 1970

EXHIBIT A-1

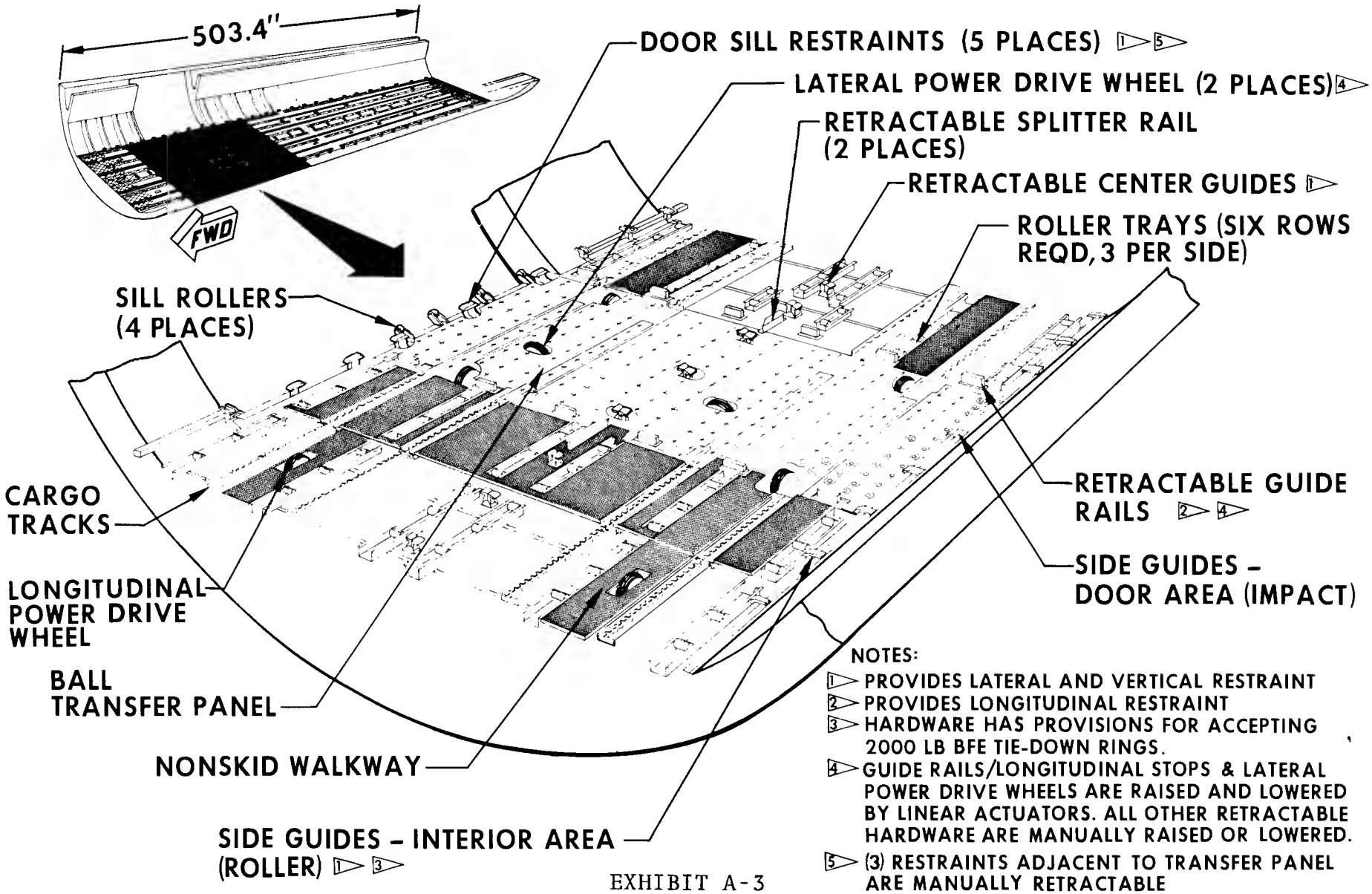
Cargo Compartment in a Boeing Airplane

EXHIBIT A-2

ECL 149A

747F

FORWARD LOWER COMPARTMENT



NOTES:

1. PROVIDES LATERAL AND VERTICAL RESTRAINT
2. PROVIDES LONGITUDINAL RESTRAINT
3. HARDWARE HAS PROVISIONS FOR ACCEPTING 2000 LB BFE TIE-DOWN RINGS.
4. GUIDE RAILS/LONGITUDINAL STOPS & LATERAL POWER DRIVE WHEELS ARE RAISED AND LOWERED BY LINEAR ACTUATORS. ALL OTHER RETRACTABLE HARDWARE ARE MANUALLY RAISED OR LOWERED.
5. (3) RESTRAINTS ADJACENT TO TRANSFER PANEL ARE MANUALLY RETRACTABLE

EXHIBIT A-3

ECL 149A

Reprinted from the issue of October 10, 1966
PRODUCT ENGINEERING ECL 149A

Masses of ball transfer units in airplane floor make it easy to shove cargo loads in any direction.

Compact ball transfer units roll loads every which way

An improved design of an oft-neglected device for moving loads—ball transfers—is opening up new applications in air cargo planes (photo above) and other materials handling jobs. It can serve in production lines to transfer sheets, tubes, bars, and parts.

Uses of established ball transfer units have been limited largely to furniture (in place of casters) and other prosaic duties. With new design that takes fuller advantage of their multiple-axis translation and instantaneous change of direction, ball transfer units can be realistically considered as another basic type of anti-friction bearing. The improved units are made by General Bearing Co., West Nyack, N.Y.

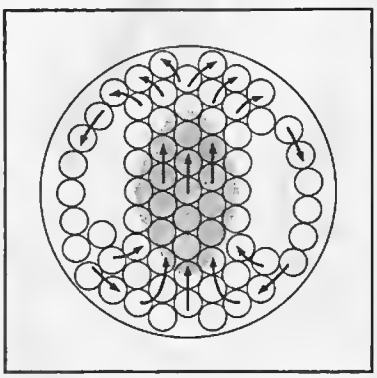
How they work. Essentially, ball transfers (photo below) are devices that translate omnidirectional linear motion into rolling motion to provide an unlimited number of axes of movement in any given plane. In such a unit, a large main ball rotates on its own center within a housing. This ball is supported by a circular group of smaller balls (drawing below) that roll under load and, in so doing, recirculate within the housing in endless chains.

These units are designed either as "ball up" or as "ball down." In the "ball down" units, design must provide a positive means of recirculating the support balls so they won't fall away under their own weight.

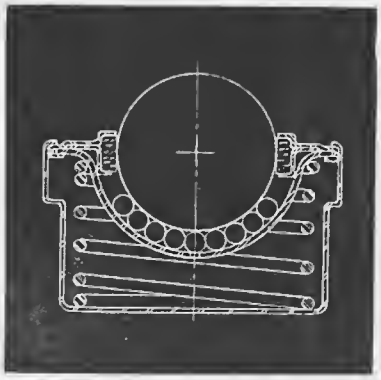
Variations. Many different configurations are available to suit the specific requirements of customers. Balls of carbon steel are most often used, but stainless steel balls are available for uses where corrosion may be a problem. Ball transfer units can be sealed to exclude dirt.

Where loads require that a number of ball transfers must simultaneously contact the load surface, a spring technique has been developed. Each ball transfer (drawing below) is spring-loaded. It starts to deflect when its own rated load is exceeded, allowing other ball transfers to pick up their share of the load. This concept also provides protection against major overloads in any ball transfer unit. □

Main ball shown, 1 in. dia., is supported by 70 smaller balls, hidden.

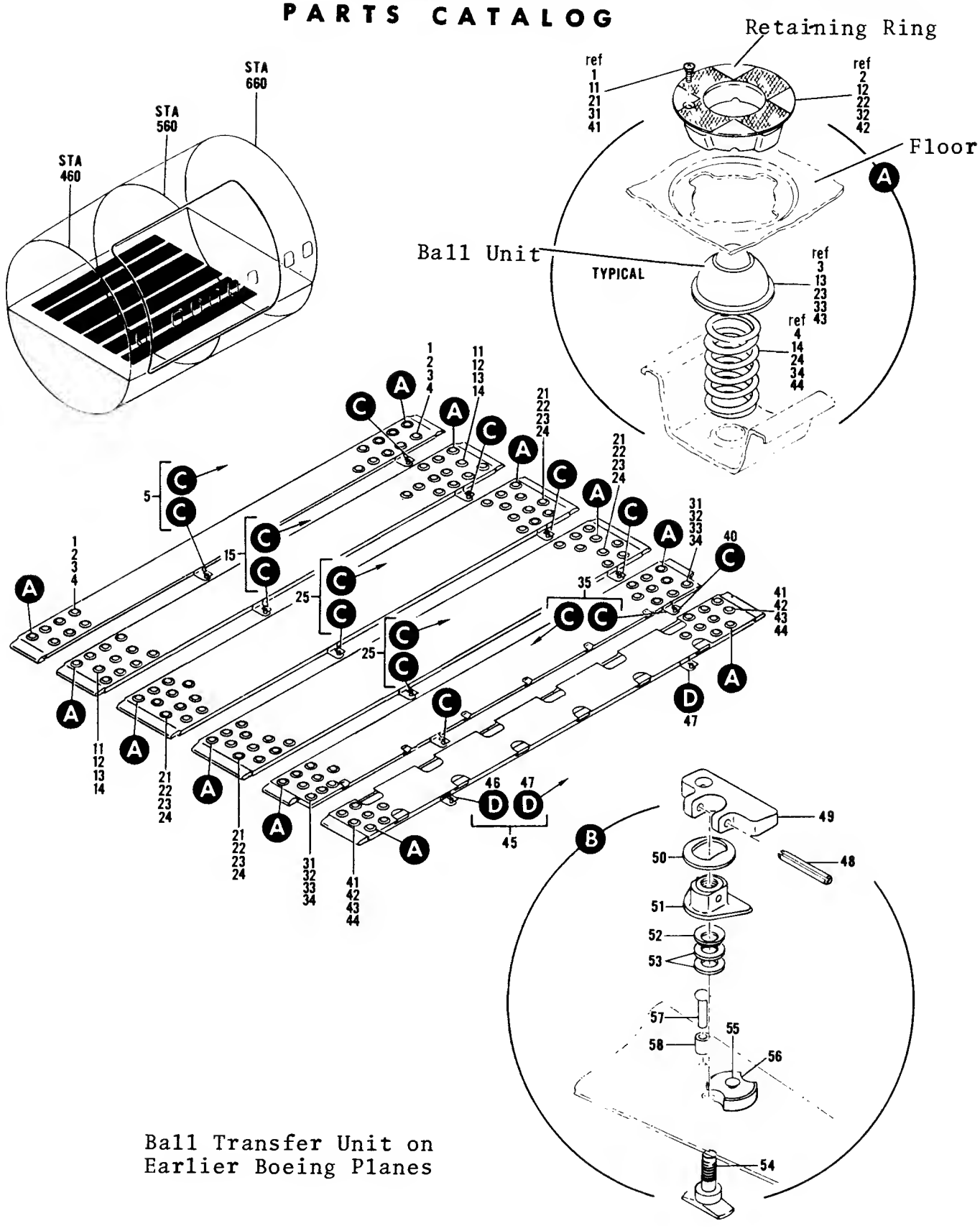


Shaded area seen from above shows load; arrows show ball circulation.



Spring loading assures even distribution of the load on the small balls.

EXHIBIT A-4



Ball Transfer Unit on
Earlier Boeing Planes

3610-4668A

PANEL ASSEMBLIES, PALLETIZED CARGO SYSTEM TRANSFER (SHEET 1)

EXHIBIT A-5

BEARINGS, SEALS, & GEARS, INC. ECL 149A

INTER-OFFICE CORRESPONDENCE

DATE April 24, 1967

TO Westscope, Inc.

ATTENTION Bud Cain

COPIES George Goodrich

SUBJECT Boeing Airplane Division
Seattle, Washington

REFERENCE 747 Cargo Ball Transfer Unit

Enclosed are Sheet 1 and Sheet 2 showing the latest configuration of the channels in which the ball transfer units will sit. The current thinking is that it will basically be a box section with a center rib with cutouts at the top and bottom to provide for ball unit restraint in the horizontal plane and also for retention in the vertical plane with a hole and snap-through assembly in the bottom of the support channels.

Please note the desired diameter of the encapsulated unit is 1.75" whereas its current height from the top of the ball to the bottom of the unit is 1.65".

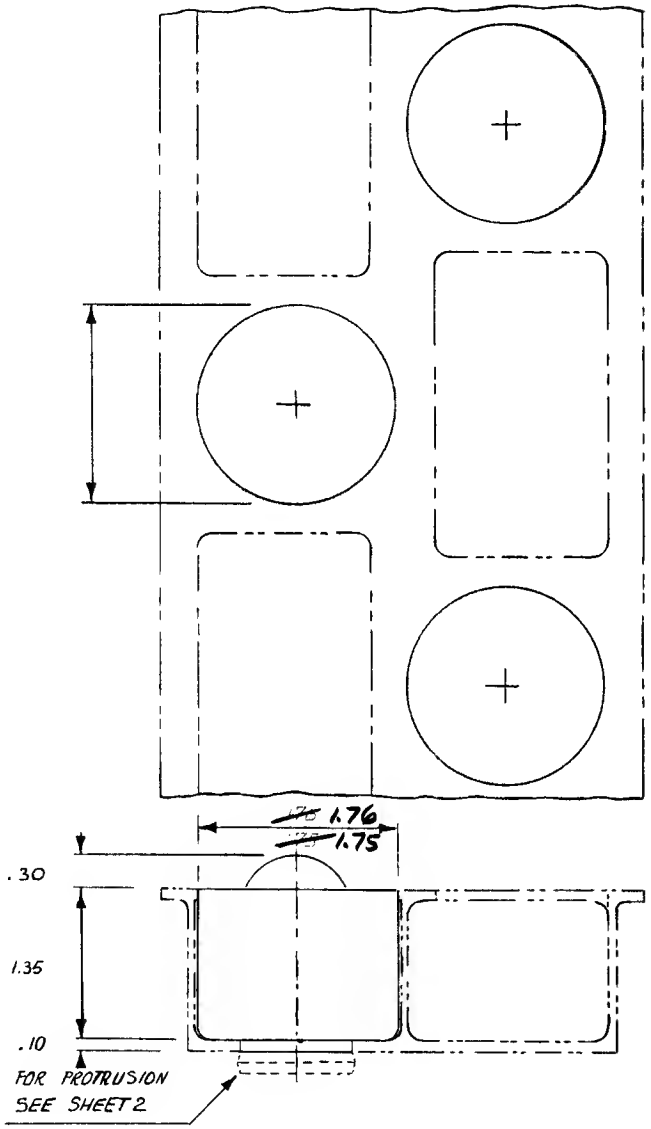
The unit is supposed to travel down and bottom at a position of .10" above the top of the channel units. The spring load at this position when travel of .20 is achieved should preferably be 150 lbs. or less. You will note the chart indicates a maximum of 200 lbs. increasing as dictated after reaching the solid spring height. However lower load would be preferred to keep the spring rates slower and hence uniform loading of the ball transfer units.

Boeing engineering currently favors the ball unit protrusion sketch shown in the center of Sheet 2. They envision currently a plastic retainer having 4 prongs that pop through the hole in the bottom of the channel and provide for vertical retention of the ball transfer unit.

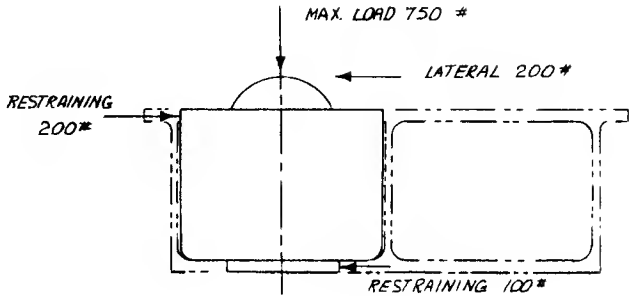
They are coming out with a letter and will be requesting proposals to be submitted by May 14, 1967, in a final form such that they can be reviewed and approved by Boeing for procurement in this application.

Excerpt from a letter from Jerry Carlson
to Bud Cain, dated 24 April 1967

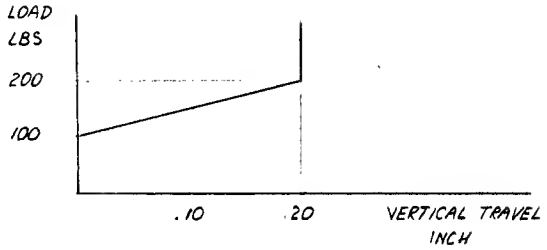
EXHIBIT A-6



1) LOADS



2)



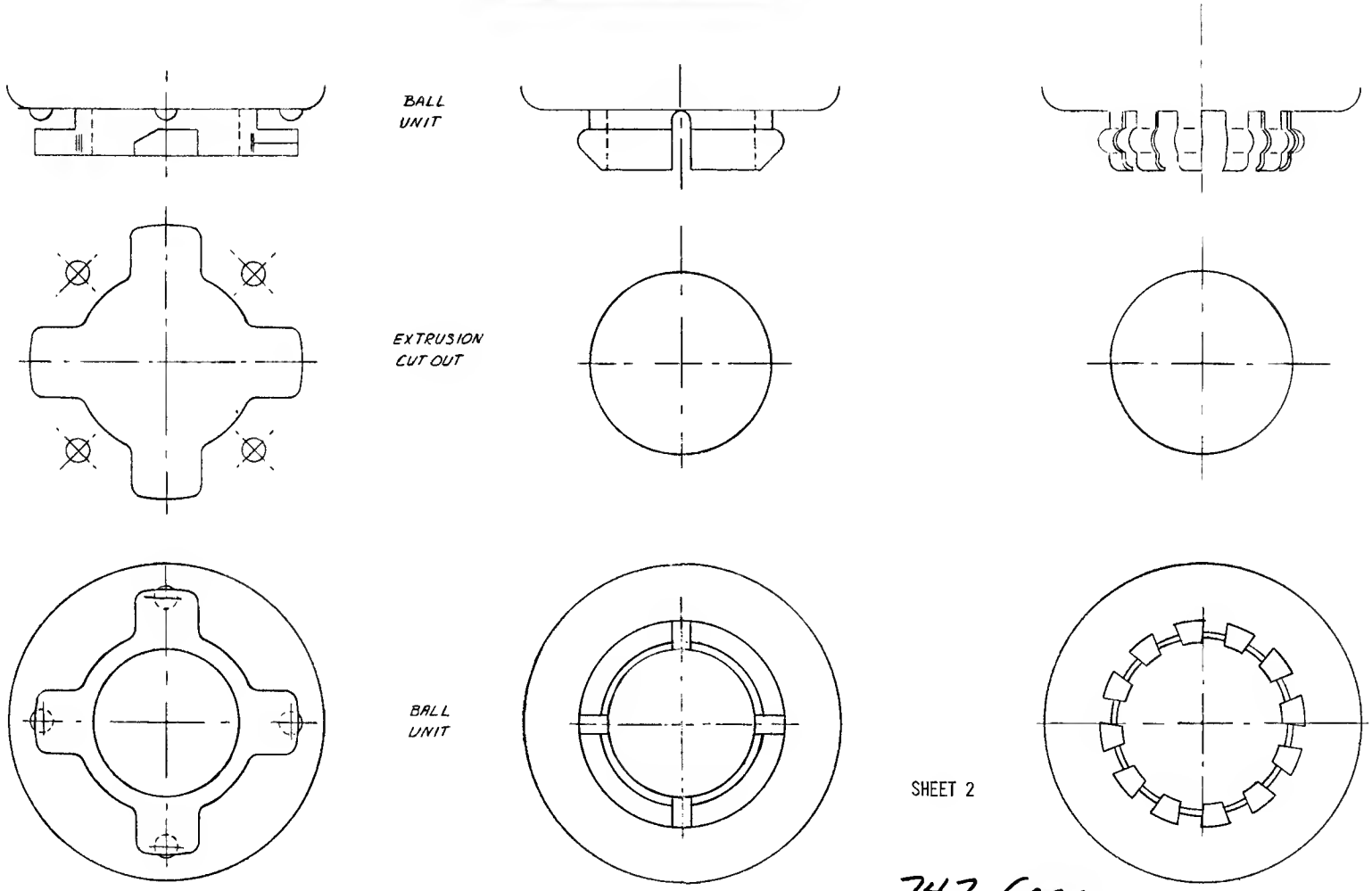
3) LIFE 300 HRS AT
BALL ROTATION 1.5 FT/SEC LINEAR (344 RPM)
WITH MAX LOAD APPLIED TO BALL

SHEET 1

747 CARGO

ECL 149A

Sketch sent by Jerry Carlson to Bud Cain
EXHIBIT A-6



Sketch sent by Jerry Carlson to Bud Cain

EXHIBIT A-6

ECL 149A

ECL 149A

THE BOEING COMPANY

COMMERCIAL AIRPLANE DIVISION · P. O. BOX 707 · RENTON, WASHINGTON 98055

April 28, 1967

IN REPLY REFER TO

E-5697-316

E. S. Cain

WESTSCOPE, INCORPORATED
c/o Jerry Carlson
6868 - 84th Avenue S. E.
Mercer Island, Washington 98040

Attention: Mr. Jerry Carlson

Subject: Ball Transfer Unit Proposal

Gentlemen:

Developments subsequent to your original submittal have changed the ball unit design criteria to that shown on the attached drawing and as follows:

1. 100 pounds of pre-load.
2. Ball will deflect for .10 inches and then rest solid.
3. Ball Transfer Unit is supported entirely by the bottom web of the support tray when subjected to a vertical down load.
4. Ball to be 1.00 inch in diameter, hollow and made of stainless steel.
5. Ball-race balls to be made of stainless steel.
6. Ball-race to be made of stainless steel.
7. Ball Transfer Unit shall support 750# in a static condition without failure.
8. Ball Transfer Unit shall withstand 550# limit load without yielding.
9. Ball unit shall be retained in its support tray by a spring retaining device in the base of the ball unit. This device shall keep the ball unit in the tray when loads of 10# vertical up and 100# side (at base of unit) are applied to the ball unit.

The ball unit will be designed to minimize the possibility of dirt or other contaminants interfering with free movement of the ball.

The attached sketch shows the current envelope of the ball unit and its support tray.

You are requested to submit your proposed design by May 15, 1967. In addition to a drawing of the unit, your design proposal should include the following information:

1. Material of each component.
2. Thickness of all material.
3. Temper or condition of each part.
4. Complete dimensions for all parts.
5. Tolerances, fabrication and assembly.
6. Spring force and spring rate.
7. Exact form and material of bottom retainer.

Please indicate the lead time for procurement of two engineering evaluation models of proposed ball units, as well as a quote indicating cost of representative production quantities. It is understood that any design or development work against this request shall be at no charge to The Boeing Company.

Your assistance in this regard is greatly appreciated.

Very truly yours,

THE BOEING COMPANY
Commercial Airplane Division

R. T. Burtch, Manager
747 Cargo Systems Procurement

Enclosure

ECL 149B

DESIGN OF A BALL TRANSFER UNIT FOR AIR CARGO (B)

On April 28, 1967, Boeing sent a request for quotation for a ball transfer unit to be used on the cargo system in Boeing 747 (Exhibit A-7). Westscope's response dated May 9, 1967 is shown in Exhibit B-1. The proposed design was based primarily on concepts suggested in Boeing's specifications (Exhibits A-6 and A-7).

 Written by R. K. Ganeriwal under the direction of Dr. Henry O. Fuchs with support from the National Science Foundation. The cooperation of Mr. Bud Cain and Mrs. Diana Jaye of Westscope, Mr. C. Y. Joe, Lloyd Eber, and Ron Wallace of the United Air Lines in San Francisco is gratefully acknowledged.

DESIGN OF A BALL TRANSFER UNIT FOR AIR CARGO

Design improvements were continued after the proposal had been submitted. "We cannot afford to just sit around and wait for things to happen," Bud explained. "We are always on the go to make sure that our competitors do not catch up with us."

The two most significant improvements in the final design, which got Westscope the contract for an initial order of 75,000 units, were a new locking device for the snap-in mechanism and a new concept which provides a positive stop for the deflection of the spring beyond a predetermined height along with an envelope for the movement of the spring.

Westscope received a patent for these innovations. Excerpts from the patent, included in Exhibit B-2 describe these features in detail. With the new locking device, the unit can simply be pressed in the floor cavity wherein the unit latches securely under the top skin of the floor panel. The latch can be retracted and the unit be removed by a simple tool such as a screw driver or a pair of pliers. The other unique feature incorporated in the design is an inner cylindrical housing which serves two purposes. This inner, and the outer housings form a cylindrical annulus to provide the main spring with an envelope and thus prevent clashing and misalignment of coils during the movement of the spring. In addition, the bottom of this housing is designed to butt against the outer housing to provide a positive stop to further spring travel.

Exhibit B-3 shows some of the correspondence between Westscope and Boeing regarding these alterations in the design.

Western Gear Inc. manufactures these ball transfer units for Boeing under an agreement which calls for a 4 1/2% royalty to Westscope on every unit sold.

LIST OF EXHIBITS

EXHIBIT

B-1 Westscope's Response to Boeing's Request for Quotation

Drawing Submitted to Boeing Showing Westscope's Part No. J-050767

B-2 Excerpts from Text of Patent No. 3,466,697

Excerpts from Drawings of Patent No. 3,466,697

B-3 Letter from Westscope to Boeing, dated May 24, 1967

Letter from Westscope to Boeing, dated June 22, 1967

Letter from Boeing to Westscope, dated July 18, 1967

westscope, inc.
MANUFACTURERS
OF
PRECISION
PRODUCTS

May 9, 1967

Mr. R. T. Burtch, Manager
747 Cargo Systems Procurement
Boeing Company
Commercial Airplane Div.
Seattle, Washington

Dear Sir:

Thank you for your letter inquiry No. E-5697-316.

We are pleased to submit Westscope Part No. J-050767. This ball transfer unit will yield all the required functions that you have outlined in your proposal request.

We would appreciate your engineering comments concerning our design and we would welcome your suggestions toward improving the design.

We could furnish two engineering evaluation samples of the proposed ball unit, J-050767, within approximately 4 weeks.

Based on the part as currently shown, we would estimate that in production quantities this unit would cost approximately $5.00 each in lots of 5000 pieces.

We thank you for this opportunity to submit our proposal and will look forward to receiving your comments.

Very truly yours,

WESTSCOPE, INC.

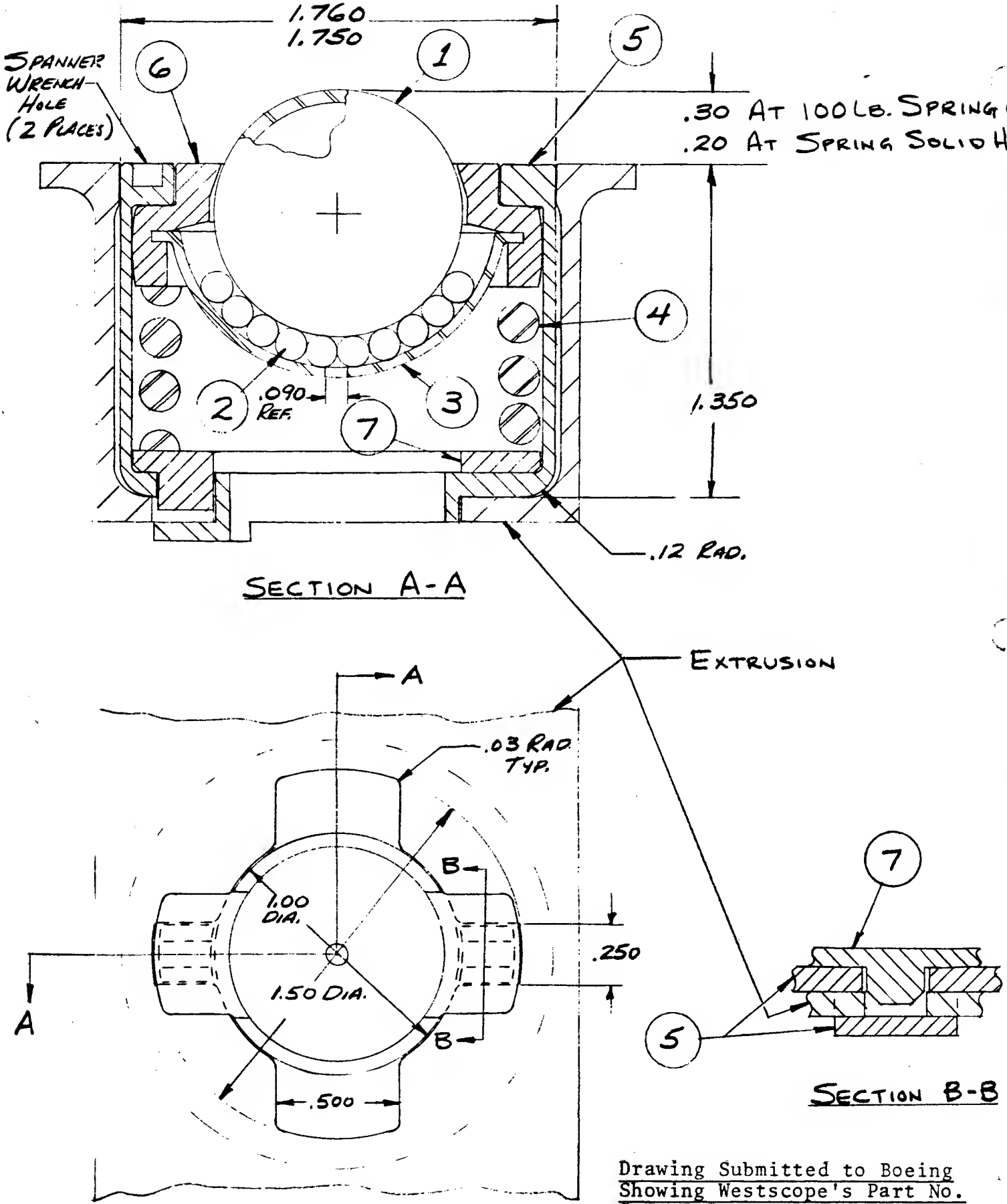
E. S. Cain

ESC:dcs
Enc..

Westscope's Response to Boeing's Request
for Quotation, dated May 9, 1967

EXHIBIT B-1

1410 MARSHALL STREET • REDWOOD CITY, CALIFORNIA 94063 • TELEPHONE: 415-369-0602



Drawing Submitted to Boeing Showing Westscope's Part No. J-050767

EXHIBIT B-1

DASH NO.	PART NAME	MATERIAL
-1	1.0" DIA. HOLLOW BALL .050 WALL THK.	440 A STAINLESS STEEL R_c 50 MIN.
-2	1/8" SOLID BALLS	440C ST. ST'L R_c 58 MIN.
-3	SUPPORT CUP .045 THK.	17-4 PH ST. ST'L R_c 45 MIN.
-4	SPRING	MUSIC WIRE .162 DIA., MEAN DIA. = 1.44, SPRING RATE = 110 #/IN.
-5	RETAINER	LEXAN, .050 MIN. THK.
-6	HOUSING	LEXAN
-7	LOCK RING	LEXAN

BALL UNIT LOAD RATINGS: LIMIT LOAD = 2,000 #
ULTIMATE LOAD = 3,000 #
2×10^6 REV. B-10 LIFE LOAD = 95 #
LATERAL LOAD = 500 #
VERTICAL UP LOAD = 250 #

BALL UNIT WEIGHT = .240 LBS.

INSTALLATION — LINE UP RETAINER LUGS WITH EXTRUSION .500 CUT-OUTS. INSERT UNIT VERTICALLY DOWN UNTIL TOP IS FLUSH WITH EXTRUSION. TURN 90° UNTIL FRICTION DRAG CEASES, USING SPANNER WRENCH HOLES IN THE RETAINER. SPANNER WRENCH HOLES WILL BE AT 90° TO EXTRUSION & WHEN UNIT IS LOCKED IN PLACE. TURN 90° UNTIL SPANNER WRENCH HOLES ARE IN LINE WITH EXTRUSION & TO REMOVE BALL UNIT.

WESTSCOPE, INC.
REDWOOD CITY, CALIFORNIA

UNLESS OTHERWISE SPECIFIED:
REMOVE BURRS AND SHARP EDGES
FRACTIONAL TOLERANCES: ± .06
ANGULAR TOLERANCES: ± 1/2°
DECIMAL TOLERANCES: ± .010

TITLE: BALL TRANSFER UNIT

DR: SEA	5-6-67	P/N J-050767	REV.
AP: MAB	5-9-67		
SCALE — 2:1			

United States Patent Office

3,466,697

Patented Sept. 16, 1969

3,466,697

BALL TRANSFER OR CASTER UNIT

Earl S. Cain, Woodside, Calif., Jerome A. Carlson, Mercer Island, Wash., and George E. Goodrich, San Carlos, Calif., assignors to Bearings, Seals & Gears, Inc., Redwood City, Calif., a corporation of California

Filed May 10, 1968, Ser. No. 728,196

Int. Cl. B60b *33/08*

U.S. Cl. 16—26 9 Claims

ABSTRACT OF THE DISCLOSURE

A spring-loaded ball transfer or caster unit including means for releasably securing the unit to structures with which it is associated and/or means serving to limit movement of the ball responsive to a load applied thereto.

BACKGROUND OF THE INVENTION

This invention relates generally to a ball transfer or caster unit and more particularly to a unit particularly adapted for use in cargo handling systems where containers are moved over transfer pallets or floors.

Prior art ball transfer units employed for this purpose have been secured to the floor or pallet by screws or bolts. As a result, considerable time is required to replace a damaged unit. Another difficulty with many prior art ball transfer units is the fact that they make no integral provision for load distribution among units on which the cargo is resting. Thus, a unit which projects a greater distance above the floor will carry a larger proportion of the total load than other units. Where spring-loaded units are employed to overcome the above excessive loads, the springs can be damaged by overload and, therefore, destroy the functionality of the unit.

SUMMARY OF THE INVENTION AND OBJECTS

It is an object of the present invention to provide an improved ball transfer or caster unit.

It is another object of the invention to provide a ball transfer or caster unit including releasable latching means for securing the transfer unit to an associated structure.

It is another object of the present invention to provide a spring-loaded ball transfer or caster unit including positive stop means for limiting the compression of the spring.

It is a further object of the invention to provide a ball transfer or caster unit with predetermined dimensions and number of support balls to provide support for the ball and smoothness of operation of the unit.

It is a further object of the present invention to provide a ball transfer or caster unit comprising a cylindrical, square, or other housing adapted to receive and hold a ball transfer sub-assembly and a spring for urging the sub-assembly upwardly. Further, the ball transfer unit includes releasable retaining means for removably holding the unit in associated apparatus for easy insertion and removal.

The foregoing and other objects of the invention will be more clearly understood from the following description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWING

FIGURE 1 is a sectional view of the preferred embodiment of the present invention.

FIGURE 2 is a top view of the ball transfer unit of FIGURE 1.

FIGURE 3 is a bottom view of the ball transfer unit.

FIGURE 6 is an enlarged view of the portion 6—6 of FIGURE 1 showing details of the latch assembly.

FIGURE 7 is a sectional view taken along the line 7—7 of the stop ring shown in FIGURE 8.

FIGURE 8 is a front elevational view of the stop ring shown in FIGURE 5.

FIGURE 13 is a sectional view of a low profile ball transfer unit in accordance with the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIGURES 1–4, the ball transfer unit shown includes a cylindrical outer housing **11**. One end of the housing is stepped inwardly to form a first stop **12**, a smaller cylindrical portion **13**, a second stop **14**, and a bottom portion **16**. The bottom portion **16** is adapted to register with an opening formed in the ball transfer unit support. The bottom portion includes a pair of projections **17** and **18** adapted to fit into and register with notches formed in the receiving structure to thereby orient the ball transfer unit.

A load spring **19** is disposed coaxially within the housing **11**. One end of the spring abuts the stop **12**. A cylindrical spring guide and stop **21** are disposed concentrically within the housing **11** and define along with the housing a pocket **22** for the spring **19**. The lower end of the guide **21** cooperates with portion **13** to form a bottom guide. One end of the guide **21** is bent inwardly to form a flange **23** which is adapted to abut the stop **14** and limit axial movement of the guide **21**. The guide **21** also guides the ball sub-assembly (to be described) during its telescoping movement and provides a positive stop to support the load whereby the spring is not damaged by excessive load. The guide also prevents tipping of the spring or clashing of coils to allow it to expand and return the sub-assembly without restriction or restraint.

FIGURE 13 shows a low profile ball transfer unit of the type described with respect to FIGURES 1–8. Like reference numerals have been applied to like parts. The housing **11***a* includes an in-turned flange **12***a* forming a spring stop and also the means for transferring weight to an associated cross beam. The spring guide and stop **21***a* has a lower portion adapted to abut the stop **12***a*. Thus, the in-turned portion of the outer housing serves as the spring stop, the overload transfer means, and also as a positive stop for the spring retainer and guide. Under normal operation, the spring transfers the applied load. When the unit bottoms under overload or excessive shock, the spring turns would overlap and bind without the overload transfer means. In other respects, the low profile unit is the same as previously described.

Thus, there is provided a ball transfer unit which is easy to assemble and simple in construction. The ball transfer unit includes provisions for limiting the movement of the ball into the unit. The ball transfer unit also includes quick-release latching means whereby the ball transfer unit can be rapidly replaced by employing a simple tool.

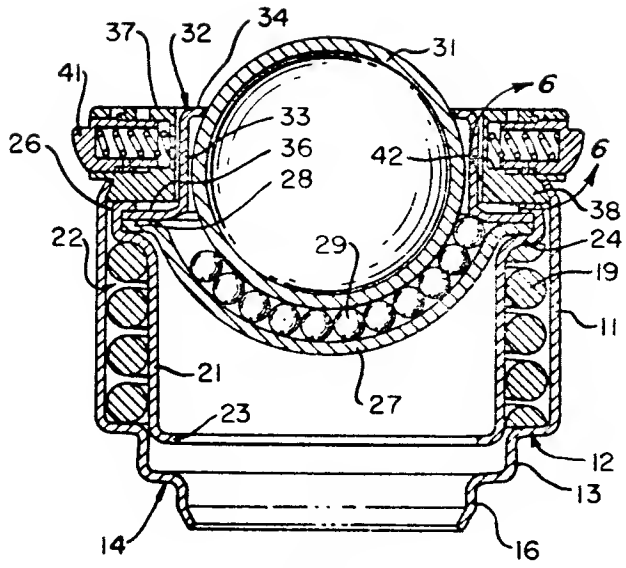


FIG. 1

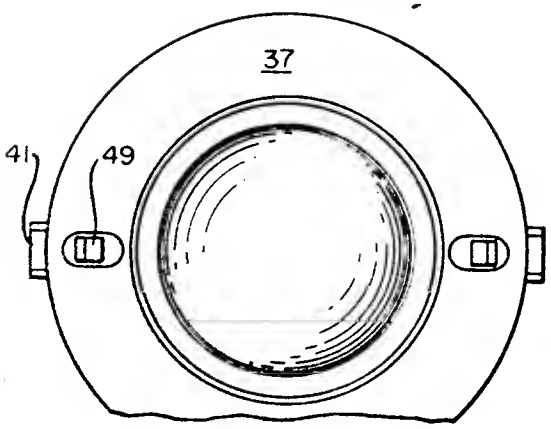


FIG. 2

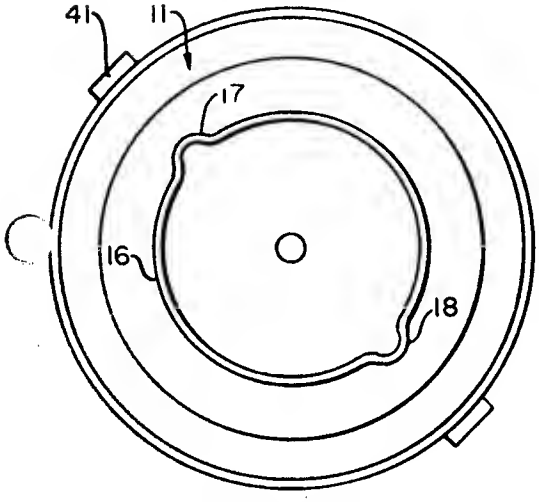


FIG. 3

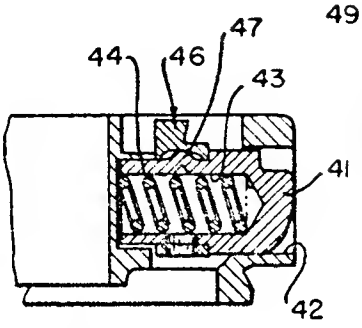


FIG. 6

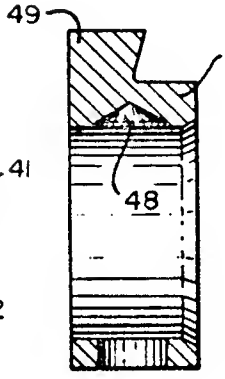


FIG. 7

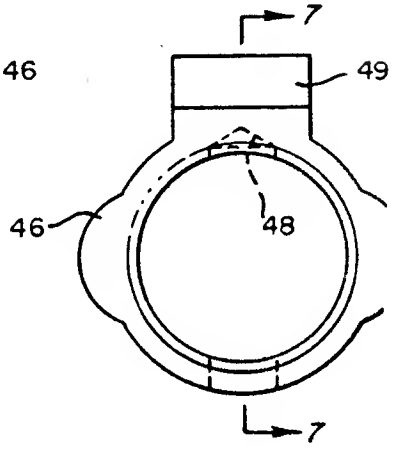


FIG. 8

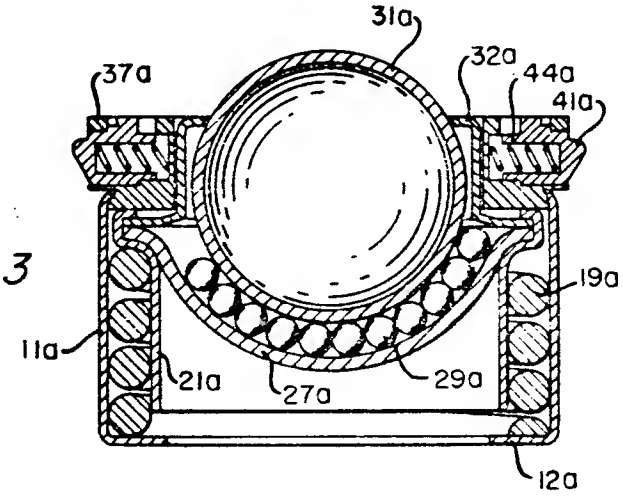


FIG. 13

Excerpts from Patent No. 3,466,697

EXHIBIT B-2

westscope, inc.
MANUFACTURERS OF PRECISION PRODUCTS

May 24, 1967

Mr. R. T. Burtch, Manager
747 Cargo Systems Procurement
Boeing Company
Commercial Airplane Division
Seattle, Washington

Reference: Your inquiry E-5697-316
Our Proposal May 12, 1967
Revised Proposal Drawing 052467 Enclosed

Dear Sir:

Since our referenced proposal, we have given further study to weight, reliability, and simplicity of the Ball Transfer Unit.

We submit herewith our Drawing 052467 and will appreciate your consideration of this alternate design for the following reasons:

1. Our testing indicated a jamming tendency on the return to position mode due to roll-over of the spring coils when fully bottomed. By providing a positive stop, leaving the spring active (not bottomed) we alleviate this hazard.

2. By further structural analysis and process testing we were able to establish more specific material thickness valves from which the calculated weight dropped to .200 pounds.

3. We have managed to simplify the channel configuration required to receive our unit and still prevent its indiscriminant rotation. A separate punching operation for the 2 previous antirotation holds is now eliminated in favor of a simple simultaneous configuring operation in the lower 1.0 diameter hole.

We trust our revised proposal will be well received and look forward to receiving your comments.

Very truly yours,
WESTSCOPE, INC.

E. S. Cain
Enc.
CC: Mr. J. A. Carlson, BS&G

Letter from Westscope to Boeing, dated May 24, 1967

1410 MARSHALL STREET • REDWOOD CITY, CALIFORNIA 94063 • TELEPHONE: 415-369-0602

westscope, inc.
MANUFACTURERS
OF
PRECISION
PRODUCTS

June 22, 1967

The Boeing Company
Commercial Airplane Division
P.O. Box 707
Renton, Washington 98055

Attention: Mr. R. T. Burtch
Material Project Manager

Reference: Your letter May 26,1967, E-5697-433
Our letter June 1, 1967
Westscope Ball Transfer Unit J-070267

Dear Mr. Burtch:

We have given further study to our Ball Transfer Unit and have incorporated several advantageous revisions in the two samples we submit herewith. The features of the unit presently are:

1. Vibration & Knockout Proof Locking Bolts: The large diameter guided locking bolts cannot be indiscriminately disengaged to permit unit getting out of its mounting hole.

2. Instant Installation: Simply snap the unit into the hole and it locks itself in place.

3. No Special Tools for Removal: Simply pull back locking bolts with any pointed object - paper clip, pencil, pick, screw driver, long nose pliers, etc.

4. Light Weight: Complete assembly at .200 lbs.

5. Full Guidance: Ball unit is supported its entire length for freedom from cocking or lock-up on action.

6. Sealing from Dirt Entry: Close clearance between ball unit cover and guard ring pilot will preclude filling the unit with dirt and debris in service.

(continued)

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7. Pallet Impact Resistance: A high strength, full circle guard has been designed to withstand any expected pallet or personnel impacts.

8. Pallet Deflection - No Sharp Corners: The guard cover radius has been designed to provide a lift type ramp to pallets having corner radii of .125 inch or more, thereby avoiding pallet damages.

9. Solid Down Stop: Load spring is prevented from going solid, thereby preventing coil clash or slip-over binding and permits low stress - infinite cycle spring life.

10. Full Top & Bottom Plate Support: Full cylindrical support of the 1.75 diameter top hole and 1.00 diameter bo tom hole are offered consistent with the wide channel vertical mounting tolerances.

11. Solid Antirotation & Orientation Means: The solid bottom can projections locate the top locking bolts to preclude indiscriminant turning and delatching the locks, yet permit a simple low cost configuration of the bottom mounting plate.

12. Sharp Mounting Hole Corners Permissible: Configuration permits straight hole punching or drilling and avoid the need for secondary rounding or chamfering the top and bottom channel mounting plates.

We have taken a system approach to the design of this ball transfer unit consistent with our own produceability and cost requirements. We trust you will look favorably upon its many specific features as they affect your system cost, weight, and reliability and look forward to hearing from you further.

Very Truly yours,
WESTSCOPE, INC.

E. S. Cain

ESC:dcs
Enc.
CC: Mr. Jerry Carlson
Bearings, Seals, & Gears

THE BOEING COMPANY
COMMERCIAL AIRPLANE DIVISION • P. O. BOX 707 • RENTON, WASHINGTON 98055

July 18, 1967

E-5697-568

WESTSCOPE, INCORPORATED
1410 Marshall Street
Redwood City, California 94063

Attention: Mr. E. S. Cain

Subject: Ball Transfer Unit Evaluation

Reference: Letter E-5697-316 dated April 28, 1967

Gentlemen:

We have evaluated the proposals sent in response to the above referenced letter but find it necessary to request you take another look at the design based on some new criteria.

Recently, the configuration and design of the 747 Cargo Baggage System was changed to reflect our airlines' desires for a capability to handle palletized cargo and to simplify the system consistent with reduced operations requirements. Included in the system redesign was the introduction of structural ball transfer panel assemblies in place of the ball trays described in our above referenced letter. The support structure and body structural elements affected by the system redesign have become firm and include horizontal beam webs located immediately underneath the ball transfer panel assemblies.

Consequently, it is necessary that the ball transfer units be redesigned in accordance with the attached sketches and following requirements:

1. The base of the ball unit will rest in a machined hole in the base web of the extrusion. Anti-rotation detents can be provided at the edge of the hole.

2. The ball unit will be restrained vertically by a feature which provides for easy installation or removal of the unit when approaching the ball transfer panel exclusively from the top side. The feature will provide for positive vertical locking of the ball unit and will be manipulated for installation or removal using only such tools as are normally found in a flight line mechanic's tool box (pliers, screwdrivers, etc.)

Other than the above expressed requirements, those requirements as identified in the referenced letter remain the same.

Due to the critical nature of this part, it is necessary that revised proposals be received as soon as possible; therefore, we request your reproposal by August 1, 1967.

Very truly yours,

THE BOEING COMPANY
Commercial Airplane Division

for N. C. Gough
Procurement Contract Administrator
Organization E-5697
Mail Stop 03-09

Enclosure

Letter from Boeing to Westscope, dated July 18, 1967

EXHIBIT B-3

ENGINEERING CASE LIBRARY

ECL 149C

DESIGN OF A BALL TRANSFER UNIT FOR AIR CARGO (C)

Some drawings of Westscope's final Ball Transfer Unit design are shown. Exhibit C-1 shows the mechanical details of the assembled ball unit. Exhibit C-2 includes drawings and some of the items which are listed on page 4 of Exhibit C-1.

 Written by R. K. Ganeriwal under the direction of Dr. Henry O. Fuchs with support from the National Science Foundation. The cooperation of Mr. Bud Cain and Mrs. Diana Jaye of Westscope, Mr. C. Y. Joe, Lloyd Eber, and Ron Wallace of the United Air Lines in San Francisco is gratefully acknowledged.

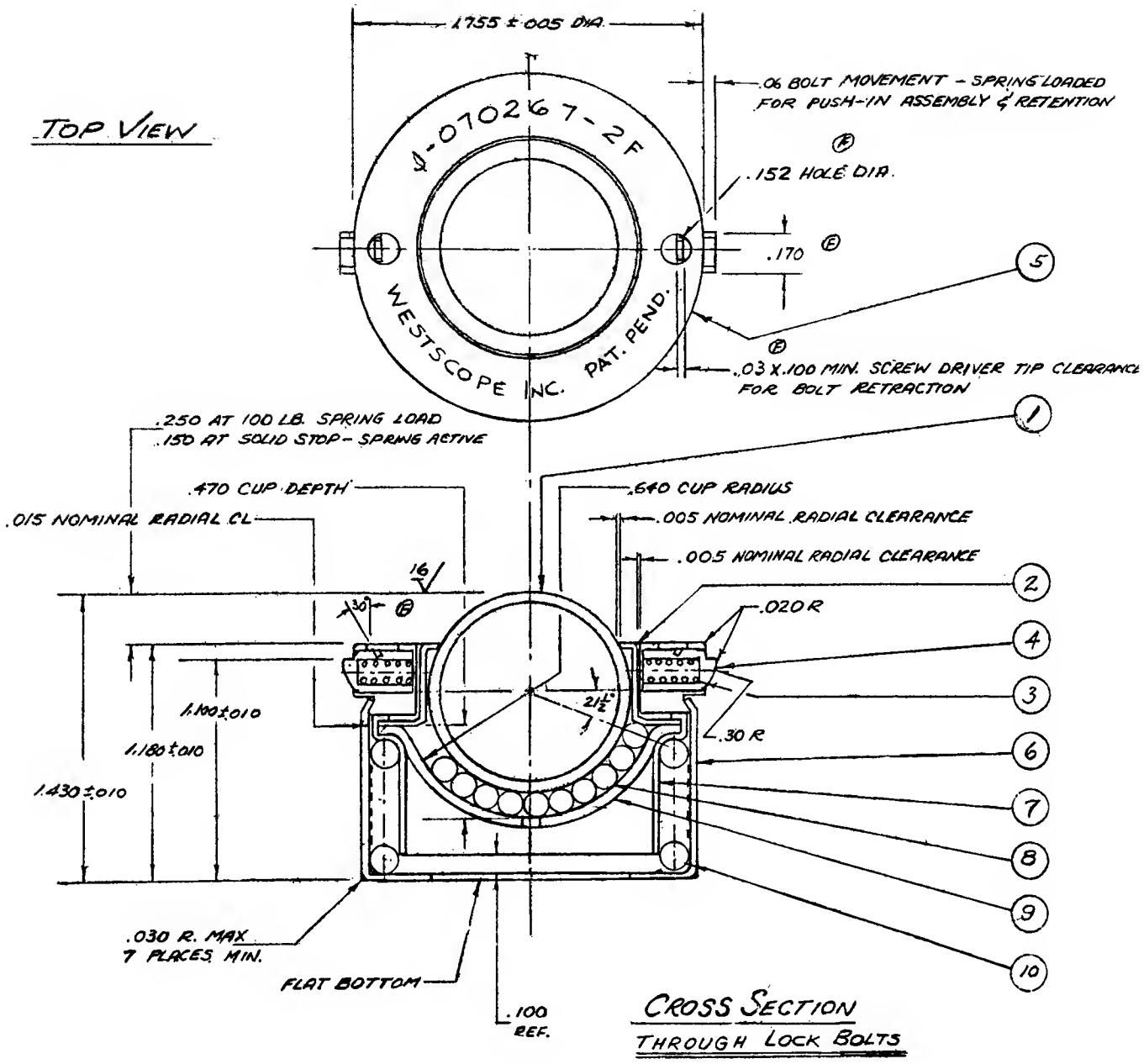
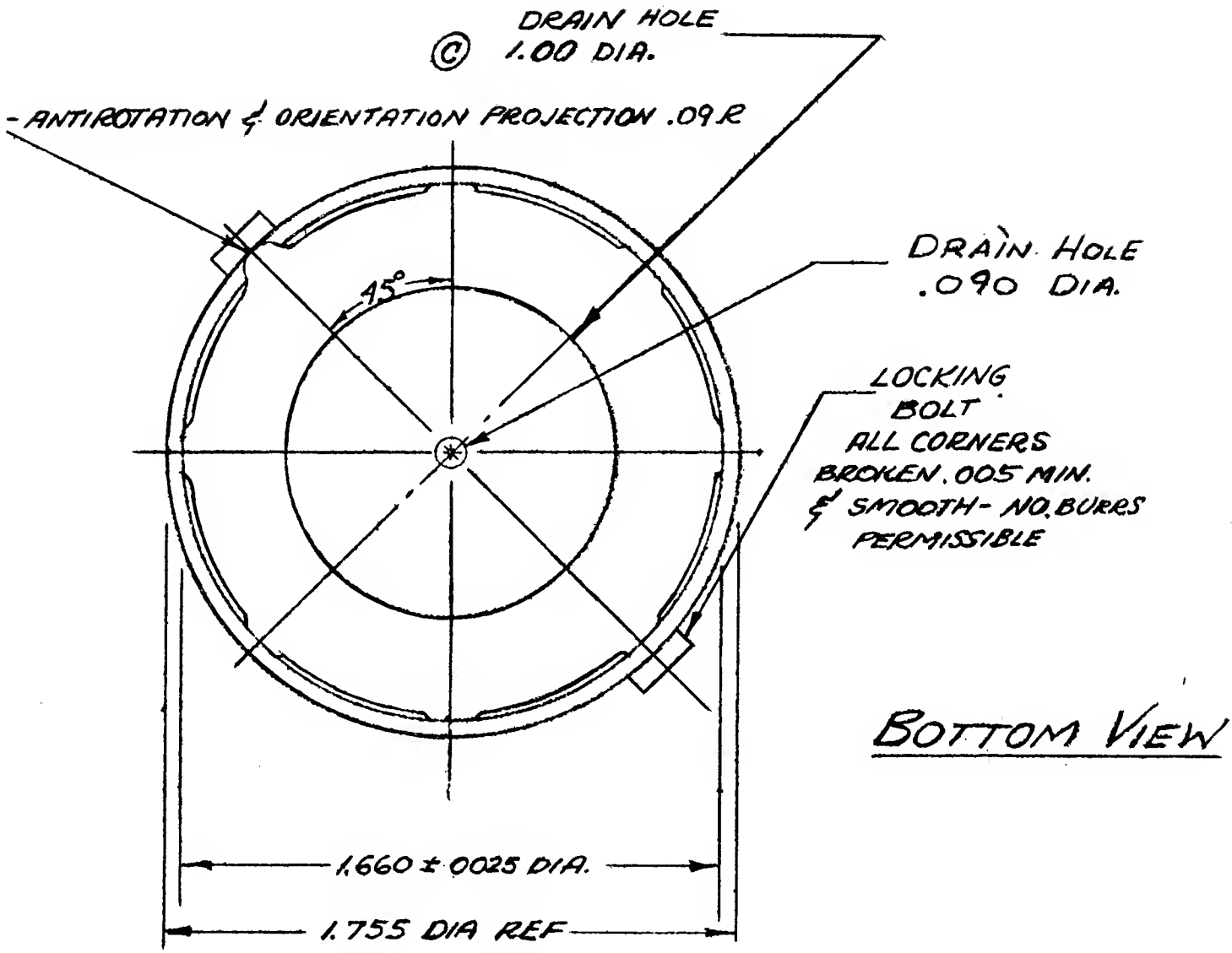

TOP VIEW
1.755 ± .005 DIA.
.06 BOLT MOVEMENT - SPRING LOADED FOR PUSH-IN ASSEMBLY & RETENTION
.152 HOLE DIA.
.170
.03 X .100 MIN. SCREW DRIVER TIP CLEARANCE FOR BOLT RETRACTION
4-070267-2F
WESTSCOPE INC. PAT. PEND.
.250 AT 100 LB. SPRING LOAD
.150 AT SOLID STOP - SPRING ACTIVE
.470 CUP DEPTH
.015 NOMINAL RADIAL CL
.640 CUP RADIUS
.005 NOMINAL RADIAL CLEARANCE
.005 NOMINAL RADIAL CLEARANCE
16
30°
.020 R
1.100±.010
1.180±.010
1.430±.010
21/2°
.30 R
.030 R. MAX 7 PLACES MIN.
FLAT BOTTOM
.100 REF.
1
2
3
4
5
6
7
8
9
10
CROSS SECTION THROUGH LOCK BOLTS

EXHIBIT C-1



BOTTOM VIEW

EXHIBIT C-1

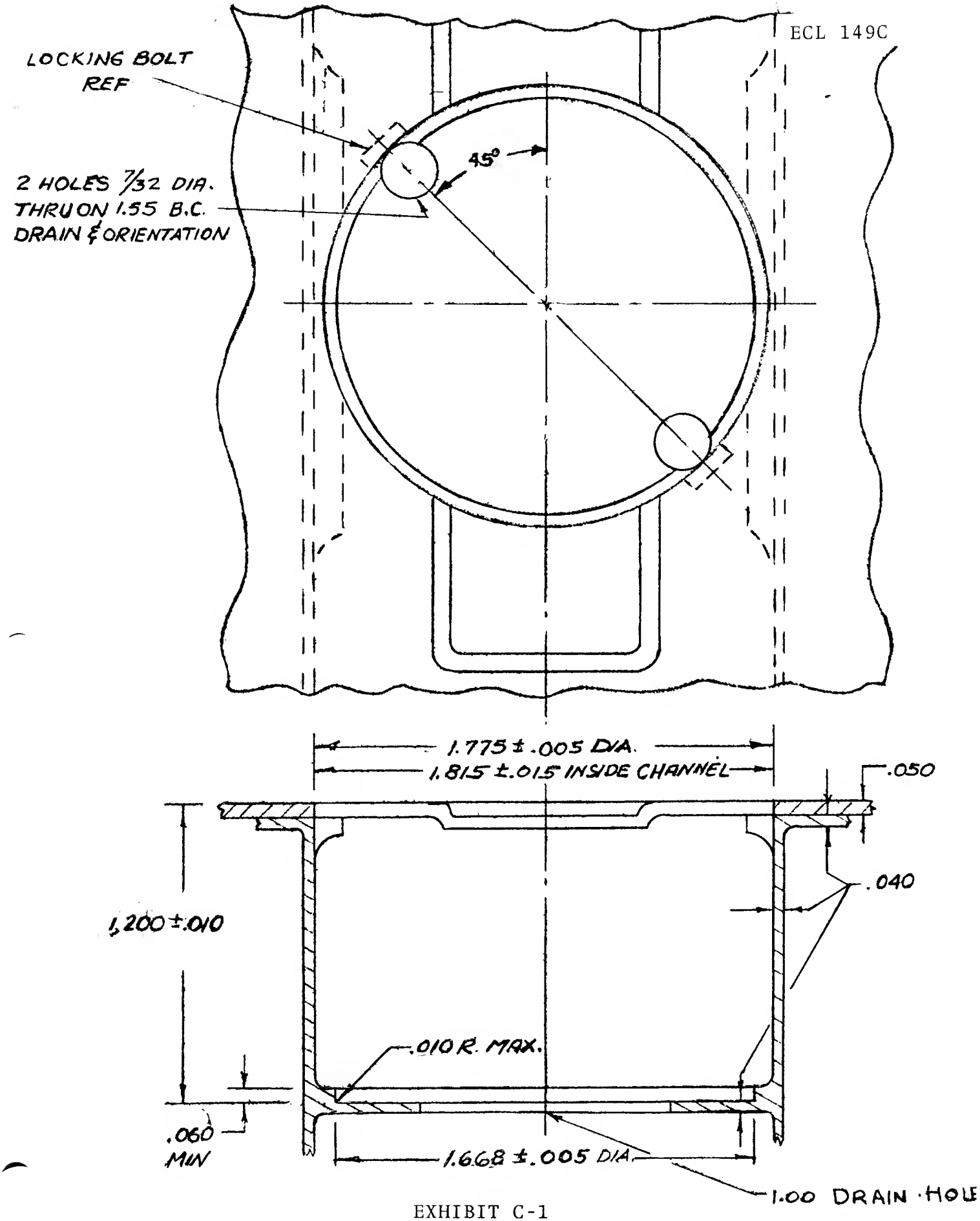


EXHIBIT C-1

DASH NO.2 LOW PROFILE UNIT MTG. REF

COMPONENT DESCRIPTION		
ITEM	IDENTIFICATION	MATERIAL & CONDITION
1.	1.00 DIA. HOLLOW BALL	.062 THICK STAINLESS TYPE 440 - WELDED - R_C52 REF.
2.	BALL COVER	.032 ALUMINUM 2024-T4 OR EQUIV. - HARD ANODIZED
3.	LOCK BOLT RETURN SPRING	.015 DIA. WIRE 17-7PH COND. 900
4.	LOCK BOLT UNIT *	STAINLESS TYPE 303
5.	TOP GUARD COVER *	ALUMINUM FORGING OR EXTRUDED BAR OR EXTRUDED TUBING 2024-T4
6.	BOTTOM CAN *	.032 ALUMINUM 2024-T4 OR EQUIV.-- HARD ANODIZED
7.	SPRING GUIDE STOP	.032 ALUMINUM 2024-T4 OR EQUIV. - HARD ANODIZED
8.	SUPPORT BALLS	70-1/8 DIA. STAINLESS TYPE 440C - AFBMA GRADE 50 - R_C56 REF.
9.	BALL RACE CUP	18 GA (.0478) STAINLESS TYPE 17-7PH R_C 45 REF.
10.	LOAD SPRING	.140 DIA. SPRING WIRE - STAINLESS TYPE NS-355 WIRE -RATE 117 #/IN.

*See Exhibit C-2 for details.

DESIGN CRITERIA	
PARAMETER	RATING
BALL FRACTURE LOAD	4000 LBS. BETWEEN PARALLEL PLATES MIN.
UNIT LIMIT LOAD	2000 LBS. MIN.
UNIT ULTIMATE LOAD	3000 LBS. MIN.
2 X 10^6 REV. B_{10} LOAD	95 LBS. MIN.
LATERAL LOAD	500 LBS. MIN.
VERTICAL UP-LOAD	250 LBS. MIN.
LOAD SPRING @100# COMPRESSION CYCLES	INFINITE
UNIT WEIGHT	.240 LBS. (F)

EXHIBIT C-1

ECL 149C

BILL OF MATERIALS			
REQ.	DRAWING	REV.	DESCRIPTION
1	090167	A	HOLLOW BALL
1	090267	A	BALL COVER
2	090367	A	LOCK BOLT RETURN SPRING
2	090467	BC	LOCK BOLT UNIT
1	090567-2	BC	TOP GUARD COVER
1	091667	B	BOTTOM CAN
1	091167	CD	SPRING GUIDE STOP
70	090867	A	SUPPORT BALLS
1	090967	B	BALL RACE CUP
1	010968	A	LOAD SPRING

SUB ASSEMBLY DRAWINGS					
DRAWING	REV.	DESCRIPTION	MADE FROM		
			PART	REV	REQ'D.
091767	-	LOAD BALL CARTRIDGE	090167 090267 090867 090967 091167	A A A B CD	1 1 70 1 1
011068	B	TOP GUARD COVER ASS'Y	090367 090567-2 010868 012968	A B AB A	2 1 2 2

EXHIBIT C-1

NOTES:

1. CONFIGURATION, MATERIALS & PROCESSES TO REMAIN UNCHANGED AFTER PRODUCTION INITIATION EXCEPT UPON WRITTEN CUSTOMER APPROVAL OF PROPOSED CHANGES, INCLUDING CHANGES TO EQUIVALENT MATERIALS.

2. PART NUMBERING DESCRIPTION REF.:

   STANDARD UNIT: J-070267-1
   LOW PROFILE UNIT: J-070267-2

3. SOURCES FOR HOLLOW BALL ITEM-1:

   INDUSTRIAL TECTONICS, INC., ANN ARBOR, MICH.
   TODECO, INC., LOS ANGELES, CALIF.

WESTSCOPE, INC.
REDWOOD CITY, CALIFORNIA

UNLESS OTHERWISE SPECIFIED:
REMOVE BURRS AND SHARP EDGES
FRACTIONAL TOLERANCES: ± .06
ANGULAR TOLERANCES: ± 1/2°
DECIMAL TOLERANCES: ± .010

TITLE: BALL TRANSFER LOW PROFILE UNIT

DR: MRB	8-18-67	P/N J-070267-1.	F
AP:			REV.
SCALE			

EXHIBIT C-1